1993. Pages 54-57 in H.C. Bittenbender, ed., Proceedings First International Macadamia Research Conference, (July 28-30, 1992, Kailua-Kona, HI)

Rodent Control Research in Hawaiian Macadamia Orchards

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ABSTRACT. During the 1990-91 and 1991-92 crop cycles, personnel at the USDA/DWRC Hawaii field station evaluated snap trapping as a means of reducing rodent populations and controlling damage in macadamia orchards. During 1990-91, 1,681 roof rats (*Rattus rattus*), 22 Polynesian rats (*R. exulans*), and 1 Norway rat (*R. norvegicus*) were captured in 4 orchard blocks. During 1991-92, capture success declined to 360 rats; species was not determined during the second crop cycle. The percentage of the total production damaged by rats varied from 0.73% to 1.34% in the trapped sections, and from 1.99% to 3.62% in the reference sections during 1990-91. During 1991-92, rodent damage ranged from 0.36% to 1.10% in the trapped sections, versus 1.71% to 2.03% in the reference sections. However, neither the number of nuts, nut weight, or total weight of undamaged full-size nuts differed between the trapped and reference sections. These results suggest the need to examine crop yield more closely in assessing methods for managing rodent infestations in orchards. The commonly used indices based on rodent activity and proportion of damaged nuts may overestimate the impact of rodent depredations and exaggerate the effectiveness of rat control measures in macadamia orchards.

Hawaiian macadamia orchards provide an ideal habitat for rats. Mature trees form thick canopies that provide nesting sites and interlocking branches that facilitate the safe movement of rats among trees. The lava rock substrate in orchards forms natural ground cavities and crevices where rats can burrow and nest beneath the orchard floor. The high oil content of mature nuts are a rich source of energy. The extended flowering and harvesting periods in Hawaii ensure an almost continuous availability of nuts throughout the year. Windbreaks and adjacent non-crop wastelands provide alternative food when macadamia nuts are in short supply.

Rats damage an estimated 5-10% of the annual macadamia crop in Hawaii (Fellows, 1982), resulting in farm losses ranging from about $2 to 4 million. Damage occurs throughout the crop cycle, from the time kernels are small, fleshy, unprotected fruits to when they are fully developed and surrounded by husks and hard, brittle shells.

Roof rats (*Rattus rattus*), also known as black rats are predominant species. They are the only one of the three species of rat found in Hawaii that regularly climbs trees. Most damage occurs to nuts on the tree, with only limited foraging on fallen nuts. In spite of their impact, little is known of the biology and impact of rats in macadamia orchards.

Biologists at the DWRC Hawaii field station recently conducted a radio telemetry study to determine nightly movement patterns of rats in a macadamia orchard, to detect seasonal differences in these movements, and to relate seasonal differences to the abundance and maturity of nuts. The study was conducted during 3 periods of the crop cycle: peak anthesis; peak immaturity, when most nuts are >110 days old, full-size, but still low in oil and lacking shells; and peak maturity, when most nuts are >200 days old, full-size, high in fatty acids; and surrounded by hardened shells.

During each of these three periods, approximately 20 roof rats were fitted with collar radio transmitters and monitored during 10 nightly tracking sessions over the course of 3 weeks. During each nightly tracking session, the location of each collared rat was determined at 2-hr intervals between sunset and sunrise. Occasional daytime readings were taken to monitor diurnal activity, to locate nests and daily resting places, and to confirm suspected mortality.

Rats typically stayed in underground burrows during the day, emerged shortly after sunset to feed in the canopy, and returned to their burrows shortly before sunrise. Rats typically remained within about 5-10 trees of their daily resting burrows. Nightly movement seemed to be more extensive during peak flowering and peak immaturity, perhaps in response to the reduced availability of nuts.

We observed only limited movement between the orchard and surrounding windbreaks. Some rats captured in the windbreaks foraged in macadamia trees along the perimeter of the orchard, but none captured in the orchard ventured out into surrounding windbreaks or non-crop areas. Thus, even during periods of low nut availability, rats apparently find sufficient food in orchards to sustain themselves.

Application of rodenticides is the main method used to control rats. Zinc phosphide currently is the only material registered in the U.S. for controlling rats in macadamia orchards. Four commercial products are registered for this purpose. Current registration labels specify three application methods: broadcasting bait on the orchard floor, spot baiting in trees, and placing bait in burrows.

Most growers in Hawaii broadcast their baits. However, the results of our telemetry study suggest that this is not an effective application technique. We did not observe any rats active on the surface of the ground, nor have we had much capture success with traps placed on the orchard floor. More study is needed to evaluate alternative application methods.

Proper timing is also critical for successful baiting. Hawaiian growers typically apply baits during the non-harvest season, when mature nuts and competing labor demands are at a minimum. Few growers control rats during the 7-9 months of the year when nuts are being harvested. Unfortunately, rats often invade orchards, build their populations, and cause extensive damage during this time.

We recently conducted a 2-yr cooperative study with the Mauna Loa Macadamia Nut Corporation to evaluate snap trapping as an alternative method of controlling damage in macadamia orchards. Trapping usually is considered too labor-intensive for most large-scale agricultural situations, but it may be cost- effective for protecting high value crops such as macadamia.

The study was conducted at the Mauna Loa Macadamia Nut Corporation orchard in Keaau, about 17 km south of Hilo, Hawaii. The 1000 ha orchard was divided into blocks separated by dirt roads and windbreaks of Norfolk Island pine trees (*Araucaria heterophylla*). We selected for study four blocks encompassing 16 to 21 ha each and containing 240 twenty-year- old macadamia trees per ha. No two study blocks were adjacent to each other.

Half of each block was selected at random for in-tree placement of 20 to 25 traps/ha. We placed the traps in adjacent rows in an alternating pattern so that adjacent trees did not contain traps. Every third row was excluded from trapping.

At approximately 6-wk intervals, during the week following each scheduled harvest, we baited the traps with chunks of coconut, secured them to lower lateral branches, and checked them daily for 2 weeks. We shut down the traps for weekends and rebaited them with fresh coconut on Monday of the second week. We removed carcasses and rebaited traps as necessary.

During the 1990-91 crop cycle, we collected 1,704 rats, including 1,681 roof rats, 22 Polynesian rats (*R. exulans*), and 1 Norway rat (*R. norvegicus*). Capture success declined to less than five rats by the end of each 2-week trapping session, but populations usually increased substantially by the beginning of the next trapping session. Nonetheless, there was a dramatic and steady decline in rat populations during the course of the study; during the second crop cycle we captured only 360 rats. Thus, snap trapping can be an effective means of reducing rat populations in macadamia orchards.

Captures were distributed fairly evenly throughout the study blocks. After trapping almost all of the rats in each block, we expected that when we returned 6 weeks later, we would capture rats mainly around the edges of the block, especially near the non-crop edge. However, the distribution data of captures 6 weeks later, indicates not only that rats re-invaded rapidly, but that they quickly dispersed throughout the block.

The costs of the project included procuring the traps, purchasing and applying the sealant to water-proof the traps, buying rubber bands to secure the traps to branches, purchasing and preparing the coconut bait, rental and gas for the 'All Terrain Vehicle', and labor for setting, checking, and re-baiting the traps. During 1990-91, total expenses, excluding those for assessing damage and yields, averaged almost $341/ha/yr. Labor accounted for more than 80% of the total cost. However, the study was conducted to collect biological data as well as to evaluate trapping as a control technique, and we feel that labor costs can be reduced substantially.

The frequency distribution of traps in each block that had one, two, more than two captures during a 2-week trapping session indicates that there is little benefit to checking traps daily. For example, in study block MO2 293 traps had only one rat capture, 45 traps had two captures, and only 12 traps had more than two captures during any trapping session. Thus, little benefit was derived from checking the traps daily and resetting those that had captures. During the second year of the study we baited and set the traps only twice during each 2-week session, at the beginning of each week. This resulted in a total average cost of about $226/ha/yr, a reduction of 34% from the cost for the first year.

One to two days before each scheduled harvest, we evaluated the effect of trapping on damage by counting the number of damaged and undamaged nuts under each of 20 randomly selected trees in each of the trapped and reference sections and estimated the percentage of nuts damaged by rats. We also weighed the harvestable nuts under each tree. Rats damaged an average of 4.8% of the nuts in the reference sections, compared to only 1.6% of the nuts in the trapped sections, during the 1990-91 crop cycle. This represents an average reduction in damage of 67%. During 1991-92, damage averaged 3.3% in the reference sections and 0.9% in the trapped sections, for an average reduction in damage of 73% during the second crop cycle. See Tobin et al. (1993) for greater detail.

Interestingly enough, the lowered populations and the reduced damage did not result in increased yields. During both years of the study, the weight of undamaged mature nuts harvested from the trapped and reference sections was almost identical. Also, neither the number of undamaged mature nuts, weight of individual undamaged nuts, or total number of damaged and undamaged nuts varied between the trapped and reference sections.

These results indicate that although extensive and persistent snap trapping reduced rat populations and lower depredations in macadamia orchards, it apparently had little effect on yields of mature nuts, at least at the levels of damage observed in this study. This calls into question the most commonly used criteria for evaluating the impact and control or rats in macadamia orchards. Estimating populations and assessing damage may overestimate the impact of rodent populations and exaggerate the effectiveness of control measures.

Nut production varies greatly among years, trees, and even branches on the same tree, and is influenced by many factors besides rats. A larger sample size may be needed to detect any reduction in yield due to the low levels of rat damage observed in this study.

Rat damage to developing macadamia nuts may have little or no effect on yields unless damage exceeds natural nut drop. Macadamia flowers and fruits abscise continuously from anthesis through fruit maturity 215 days later. Of the 200 to 300 flowers on a typical macadamia raceme at anthesis, less than 1% develop to maturity (Sakai and Nagao, 1984). Levels of rat damage encountered in this study may be insignificant compared to premature nut drop due to other causes.

Trees may have compensated for rat damage by retaining nuts that might otherwise have dropped prematurely. In other words, interactions among nuts on a single raceme may control abscission, and low levels of damage may simply determine which nuts drop. Next year, we plan to simulate varying degrees of rat damage throughout the crop cycle and determine the effects on yields.

Literature Cited

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